Dr. Albert H. Wright, instructor in neurology and vertebrate zoology in Cornell University, has been promoted to be assistant professor of zoology. Arthur A. Allen has been appointed assistant professor of ornithology in the college of agriculture.

DISCUSSION AND CORRESPONDENCE

ELEMENTARY MECHANICS

To the Editor of Science: Four or five years ago we received several letters from our physics friends criticizing our discussion of Newton's laws of motion. One of these criticisms related to our use of the term "unbalanced force." If action and reaction are always equal and opposite they must balance each other, as some people seem to think, or in other words, it must be impossible for a body to be acted upon by an unbalanced force!

We swear by the God of Simplicity! A mule pulls forward on a cart with a force A, and the ground pulls backwards on the cart with a force B. If A and B are equal, the cart is acted on by balanced forces; but if either is greater than the other, the forces are unbalanced and the cart gains or loses velocity. The force with which the mule pulls *on the cart* and the necessarily equal and opposite force with which the cart pulls backwards *on the mule* can not balance each other because they do not act on the same body. You can not keep a thief from setting your pocketbook in motion by hanging tenaciously to a lamp post! and yet the ideas of action and reaction which are soberly held by many of our most pretentious teachers of mechanics mean exactly that when reduced to intelligible terms! Some of those who make a mess of action and reaction are like the Missouri purist who would wish to invent a fancy way of saying that Iowa is *north* of Missouri in order to avoid a verbal battle with the man from Iowa who insists that Missouri is *south* of Iowa.

Another matter has entered into the recent discussion of elementary mechanics in Science, namely, the question as to the fundamental equations of dynamics. Professor Huntington[1] is certainly wrong in claiming that the fundamental facts of Newton's second law are covered by the statement that the acceleration of a given body is proportional to the accelerating force.

[1] Science, February 5, 1915.

It is very important to distinguish clearly between the conventional content and the experimental content of Newton's second law of motion concerning the accelerating effect of an unbalanced force. There are two[2] more or less distinct points of view concerning this matter as follows:

1. We may adopt the stretch of a spring as the basis of force measurement. Then to a fair degree of accuracy *experiment shows* that the acceleration of a given body is proportional to the accelerating force; and *experiment also shows* that the acceleration which is produced by a given unbalanced force is inversely proportional to the mass of the accelerated body. In this statement the mass of the body is understood to be the result obtained by weighing a body on a balance scale.

2. We may agree to consider one force as

[2] Some physicists are inclined to a third point of view which makes nearly the entire content of Newton's second law conventional. The ratio of two forces is defined as the ratio of the accelerations produced by the respective forces when they are made to act, one at a time, on a given body (experiment only can show that the ratio so measured is the same whatever body be used); and the ratio of the masses of two bodies is defined as the inverse ratio of the accelerations produced in the respective bodies by a given force (experiment only can show that the ratio so measured is the same whatever force be used). From this point of view it is considered as a discovery that the ordinary centuries-old balance scale can be used to measure materials!

Consider any operation which always yields the same numerical result when applied to a given batch of sugar, but which yields a different numerical result when applied to a part of the batch. Such a numerical result can be used as a measure of the quantity of sugar, and if any such operation yields an invariant numerical result of extreme precision that particular operation should be taken as the quantitative definition of mass, if mass is to mean quantity of matter; but we should never forget that the adoption of any particular measure is essentially arbitrary.

twice as great as another when it will produce twice as much velocity per second when acting on a given body. It follows from this agreement that the acceleration produced by an unbalanced force is proportional to the force if the mass[3] of the accelerated body is given; and *experiment shows* to an extreme degree of precision that the acceleration produced by a given force is inversely proportional to the mass of the accelerated body. In this statement the mass of the body is understood to be the result obtained by weighing the body on a balance scale.

The great advantage of the second point of view lies in the fact that the accelerating effect of a force affords a satisfactory basis for precise force measurements; and the only advantage of the first point of view is that the stretch of a spring is easily measured and easily connected with our muscular sense.

The experimental content of the second point of view as above outlined may be derived from the simple experimental fact that *two bricks fall with the same increasing velocity and therefore with the same acceleration as one brick.* Fig. 1 shows the pull of gravity F

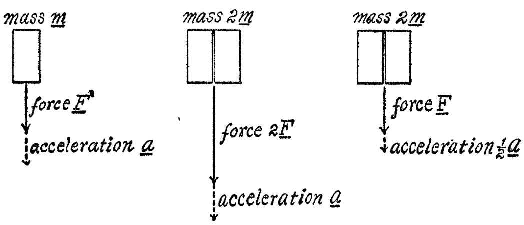

FIG. 1. FIG. 2. FIG. 3.

on one brick of mass m, and the acceleration produced is a. Fig. 2 shows the pull of gravity $2F$ on two bricks of mass $2m$, and the acceleration produced is a. Now suppose we reduce the force on the two bricks to half the value it has in Fig. 2, then according to our agreement[4] the acceleration produced will be halved, as indicated in Fig. 3. Then by comparing Figs. 1 and 3 we see that the acceleration produced by a given force is halved if the mass of the accelerated body is doubled.

The accelerating effect of an unbalanced force is the starting point of the science of dynamics, and the importance of the above discussion can not be overestimated. It must be remembered, however, that there is an extremely wide variety of effects which forces produce. Thus one may exert a steady pull on a body *to overcome friction and keep the body in motion;* one may exert a steady pull on a spring *to keep the spring stretched;* a ball bat exerts a great force on the ball *in setting the ball in motion;* steam *is condensed* into water when it is compressed; ice *is partly melted* when it is compressed; and so on.

Another matter which is always dragged into every discussion of elementary dynamics is the distinction between mass and weight, and although men like Professor Hoskins[5] are never confused thereby, others are confused hopelessly.

By a certain weight of material we nearly always mean in everyday life an amount of material as measured by a balance scale. Thus we speak of ten pounds of sugar or five tons of coal as weights of these substances. This popular meaning of the word weight is the precise and accepted meaning of the word mass as used by scientific men. Coal dealers and scientific men use the same units of mass, namely, the pound or the kilogram, whereas a diminishing group of engineers would have us measure coal in terms of what John Perry has, in semi-ridicule, called the "slug," the

[3] Strictly, if the accelerated *body* is given, because experiment only can show that a given force will produce the same acceleration in different bodies of the same mass.

[4] Our agreement to consider F as half as great when a is half as great does not, in all strictness, apply here. Of course we can, by definition, consider the pull of the earth on one brick to be half as great as the pull of the earth on two bricks, but experiment only can show that the pull of the earth on one brick would, if applied to two bricks, produce half as much acceleration as the pull of the earth on two bricks! This statement and the statements given in the previous footnotes are intended to convey some idea as to the immense amount of experimental fact there is in Newton's second law of motion, however we may attempt to simplify it by agreements as to formal definitions.

[5] SCIENCE, May 7, 1915, pages 684–685.

amount of material which would be accelerated at the rate of one foot per second per second by the gravity pull of the earth on a one-pound body at 45° north latitude and at the level of the sea.

The word weight according to scientific usage means the force with which the earth pulls on a body, and it can be expressed most intelligibly in dynes or poundals.

Many teachers of engineering conform to the popular usage in that they employ the word weight to designate the absolutely definite and invariant result which is obtained by weighing a body on a balance scale, and to get what they call the "mass" of the body they divide this so-called weight by the acceleration of gravity which is a variable! They do not remember, as Professor Hoskins does, that they should use the value of the acceleration of gravity at a certain place which has been agreed upon, and this is equivalent to saying that they do not understand what they are doing when they divide by "*g*." We wish indeed that the thing were as simple as Professor Hoskins thinks[6] it is, namely, a mere matter of dividing by 32.1740; and of course it is just that simple —to the man who understands it.

W. S. Franklin,
Barry MacNutt

[6] See footnote on page 685, Science, May 7, 1915.

PRE-WISCONSIN GLACIAL DRIFT IN THE BOSTON BASIN

To the Editor of Science: During the past few weeks exposures have been made in connection with extensive excavation work in the city of Boston where one, and possibly two, pre-Wisconsin drift sheets have been uncovered.

The evidence consists of a zone of extremely weathered material beneath the Wisconsin drift, an erosion unconformity, different types of deposits, a slight trace of an interglacial soil, some interglacial subsoils, and an apparent difference in direction of the source of included debris. It was possible to determine with some accuracy the zone of post-Wisconsin oxidation, and the final shaping of the ridge in which this evidence was found appears to be due to the re-advance of an ice sheet which slightly contorted the uppermost waterlain materials. The axis of this ridge is accordant with the direction of the striæ of the last glacial advance in the region.

A paper is now in preparation covering in more detail this important clue to older Pleistocene deposits in eastern Massachusetts.

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A SERIOUS NEW WHEAT RUST IN THIS COUNTRY

On May 21 of this year, a party representing the office of cereal investigations of the U. S. Bureau of Plant Industry discovered the yellow leaf rust (*Puccinia glumarum* Eriks. and Henn.) of wheat on several varieties of wheat in a field in the vicinity of the Indian school at Sacaton, Ariz. The presence of the rust was first called to the attention of the party by Dr. F. Kølpin Ravn, of Copenhagen, Denmark, temporarily employed by the U. S. Department of Agriculture in consultation with officials of the department on cereal diseases. At about the same time, A. G. Johnson found the rust also on *Hordeum murinum* in southern California. The rust was not afterwards found on wheat anywhere in California, but later, during June, was found in considerable abundance at various places in Oregon and Washington, and to some extent in Idaho, and a very few specimens at Bozeman, Mont., and Logan, Utah. Up to July 1 it has not been seen anywhere east of the Rocky Mountains. In Oregon and Washington the rust was also found on barley, and at Pullman, Wash., it was found by the writer on a species of wild grass as yet unidentified.

In various minor ways Dr. Ravn has been of great help to the cereal pathologists, but the discovery of the presence of this rust is a particularly interesting example of the benefit resulting from a cooperation of foreign botanists occasionally in the investigation of problems in this country with which such men are already acquainted in their own country. This rust being common in Europe and usually the